# Light Dark Matter Group Plans

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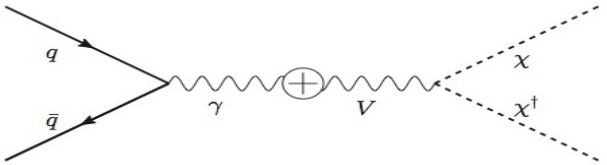
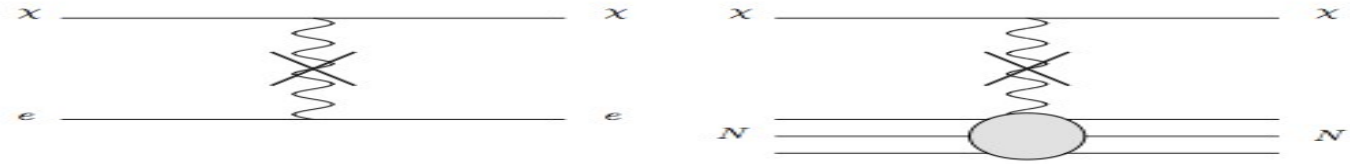
# Introduction

- We study the search for light dark matter at the Near detector location of the DUNE experiment
- Simplest Dark Photon model used for the DM production
- DM production :



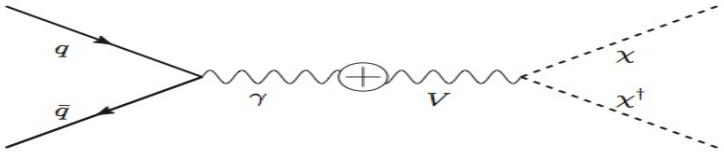

- Dark Matter detection:




We are using electron channel as a first step, will also include nucleon channel in our analysis

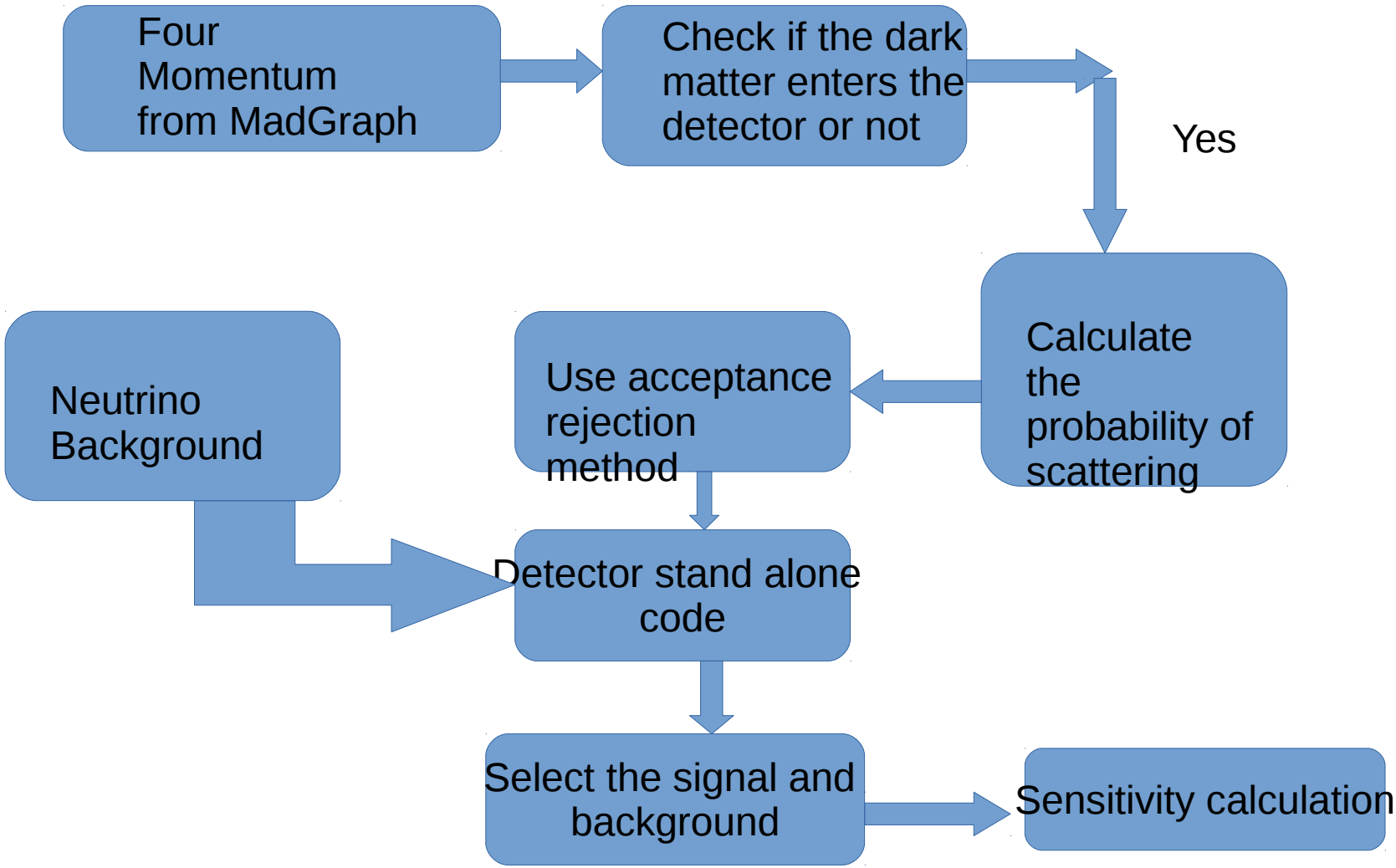
# Dark Matter Generation

- 10 Million Dark Matter events are generated using Madgraph5 MC generator for each parameter
- 80 GeV Proton Beam energy



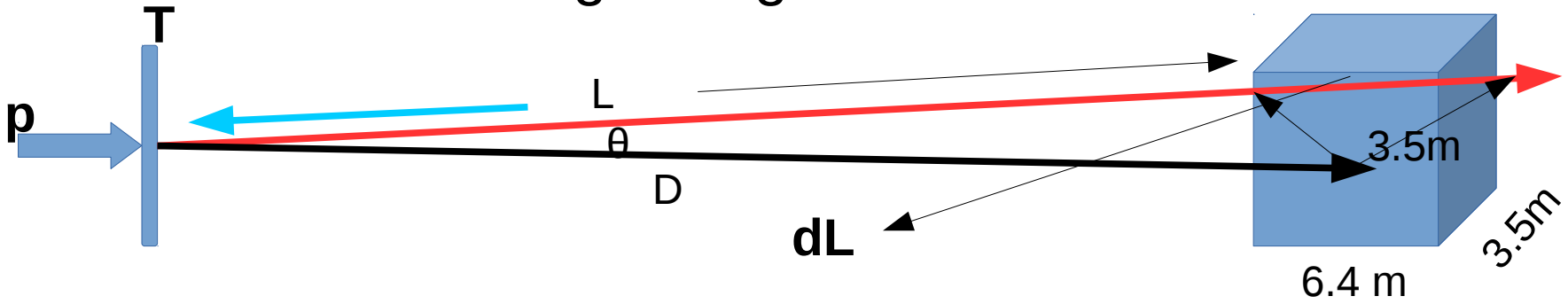

- Dark Matter four-momentum stored in ROOT file
- ROOT is the input for the next stage.
- Cross-section, Detector MC is generated using stand alone c++ code.

# Schematic diagram



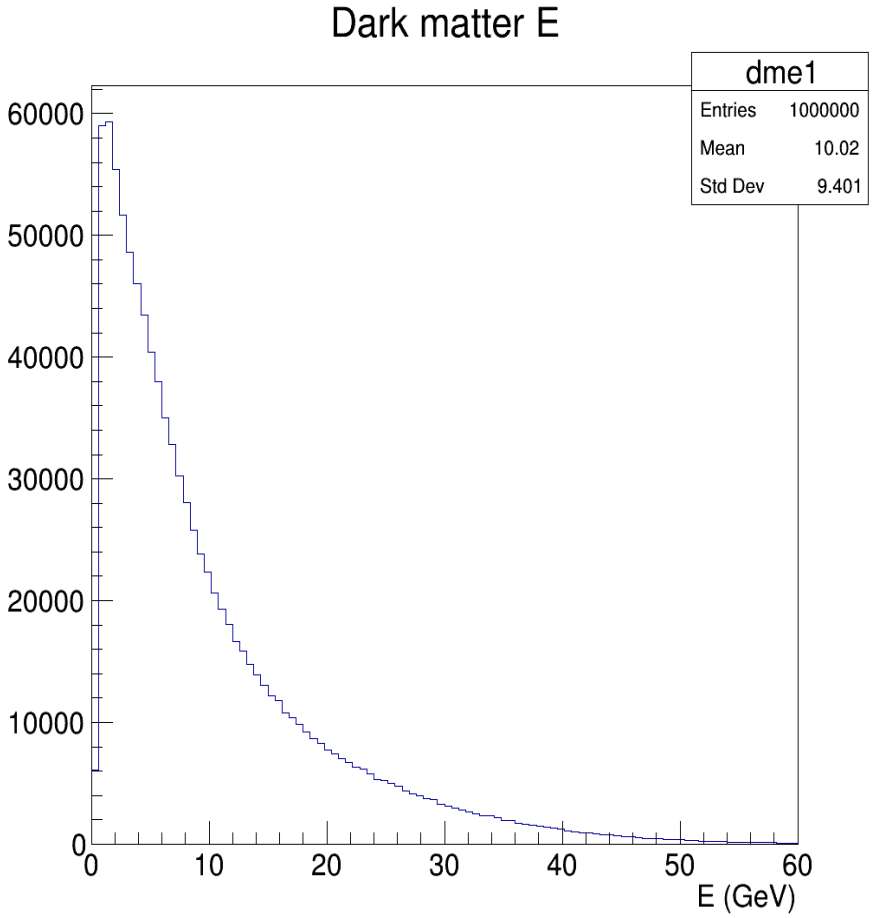
# DM Simulation @DUNE

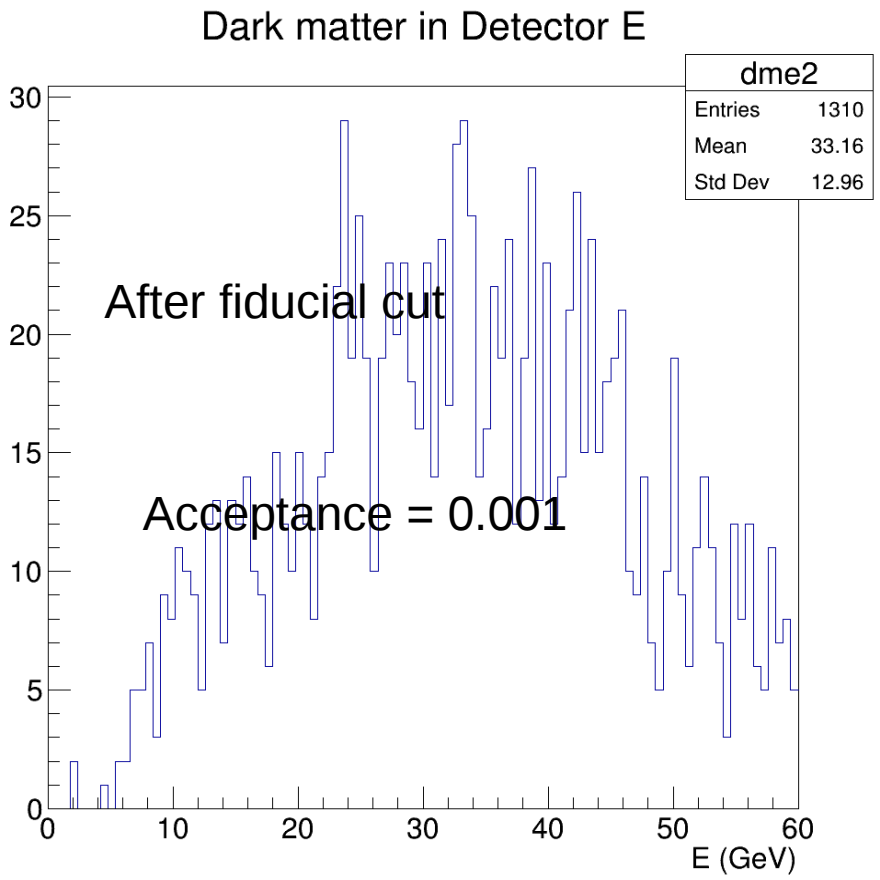
- We have the following configuration




  - We generate 10 million DM events using MadGraph5 in Fixed Target mode
  - The detector is located at a distance D = 570 m from target.
  - The fiducial volume of the detector is 3.5m x 3.5 m x 6.4 m.
  - The distance DM crosses the detector is dL
  - Dark matter mass and parameter used as Mv= 1.5 GeV, Mx= 0.5 GeV, α =0.1 , K = 0.001

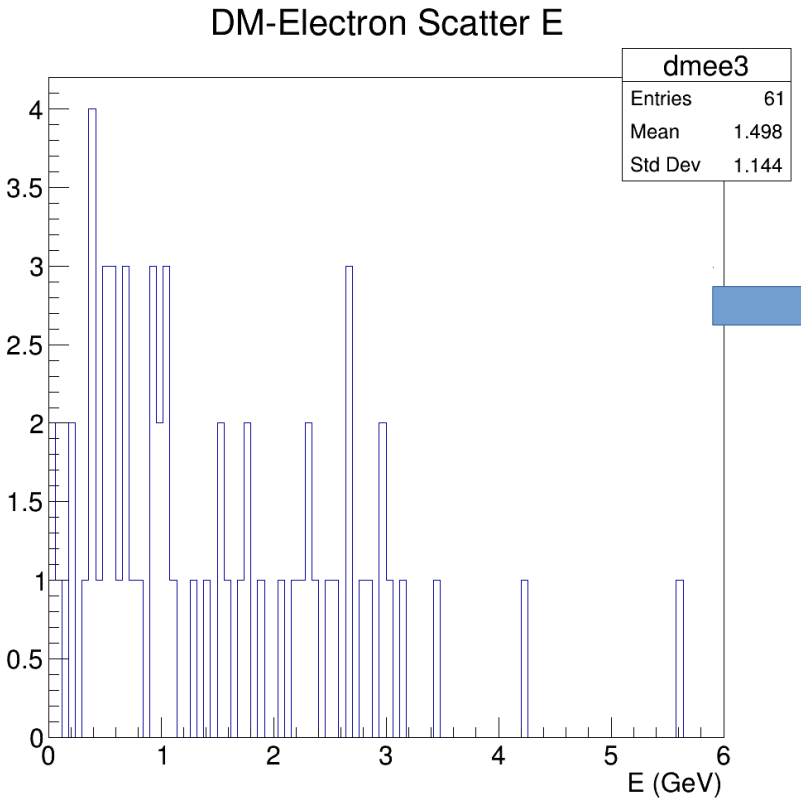
# DM energy Distribution (10 million DM events)

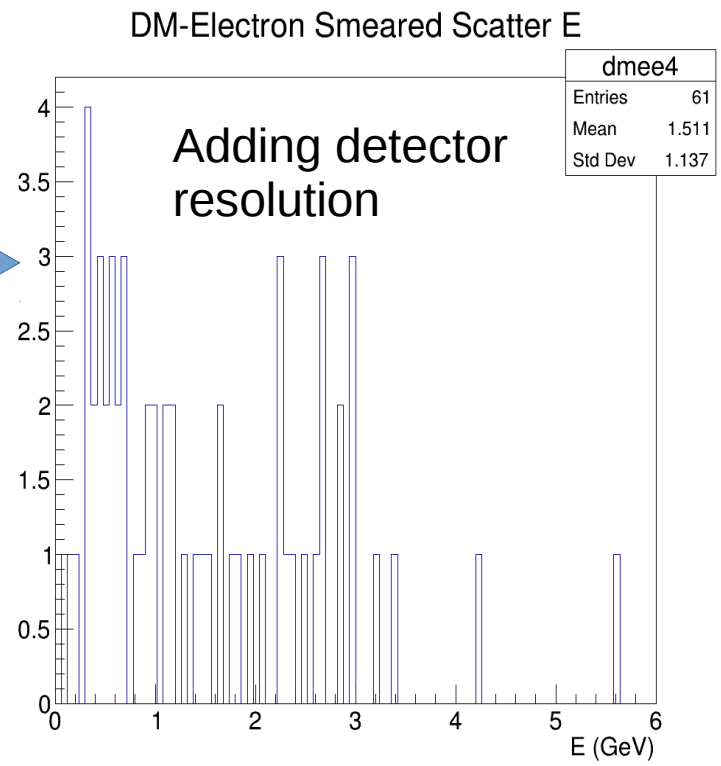


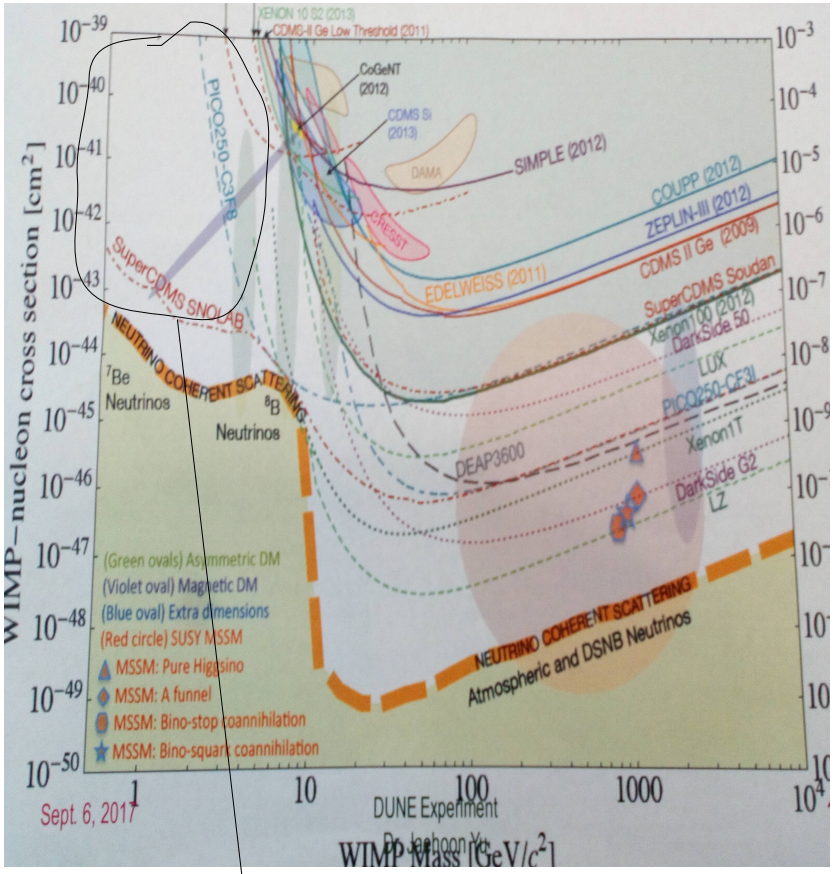

**$M_x$ = 0.75 GeV, $m_v$ = 2.25 GeV, $\alpha'$ = 0.1, k= 0.001**

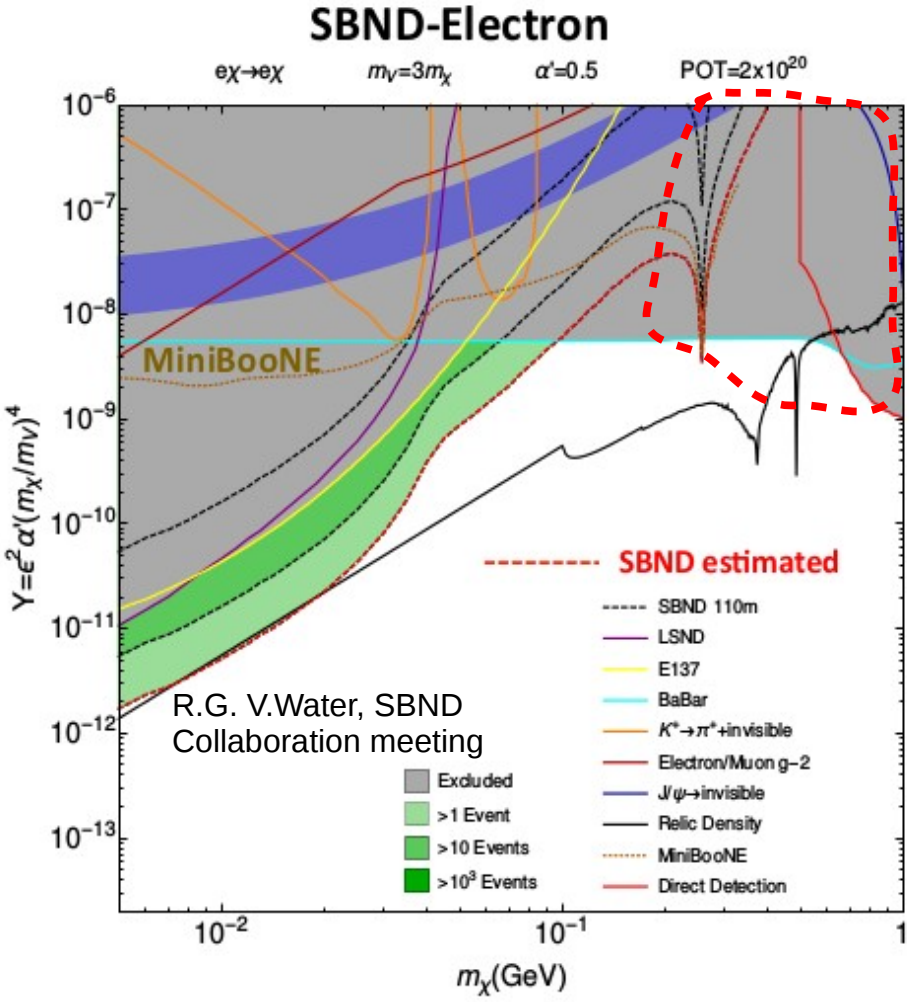
# Scattered electron Energy distribution



# Current limit on LDM parameter space




Parameter space to scan

# Preliminary sensitivity calculation

- The annihilation cross-section is defined as

  $\sigma v \sim \alpha' k^2 \alpha (m_x^2 / m_v^4)$

- The variable used in literature

  $Y = \alpha' k^2 (m_x / m_v)^4$

- The region of parameter space scan

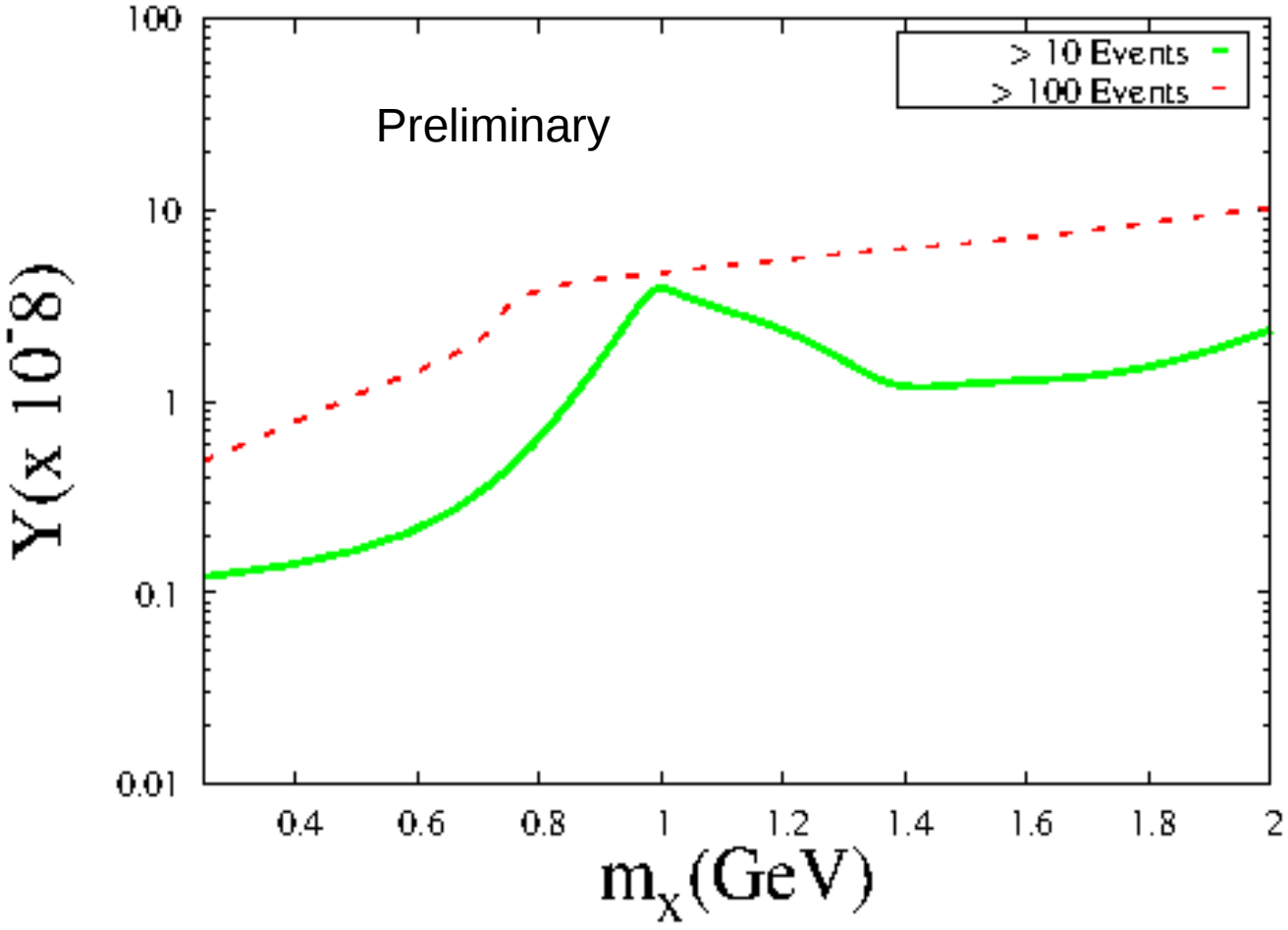
  $m_x$ = 0.25 GeV to 2.5 GeV (0.25 GeV steps)

  $m_v = 3 * m_x$

  $\alpha' = 0.1$, $k \rightarrow (10^{-3}$ to $10^{-2})$

Preliminary sensitivity calculated assuming no neutrino background, result shown for dark matter mass from 0.25 GeV to 2 GeV

# Preliminary sensitivity with zero neutrino background



# Status and plan

- Need to generate dark matter events for 10^20 POT for each dark matter parameter (normalized with neutrino background)
- 10^20 POT correspond to more than 10 million events (depends on production cross section)
- Each run takes about 10 min with 8 threads on my personal 3.4Ghz 8 core computer. Leading to a run time of about 2 months
- A more viable option is to use Fermilab cluster to distribute the runs as jobs
- We plan to use Fermilab’s grid with condor as the job manager to accomplish this.

# Plots to include for TDR

- **Dark matter at the production location:**
  - a. Energy distribution
  - b. Theta (pz/p) distribution
  - c. pz distribution
- **Dark matter distribution after fiducial cut**
  - a. Energy distribution
  - b. Theta distribution
  - c. Pz distribution

# Plots to include TDR

- **DM-electron scattering signal**

  a. Electron E distribution before smearing
  b. Electron E distribution after smearing

  c. Electron theta distribution

- **Timing of the dark matter events**

  **a.** Time delay between neutrino and dark matter events for different dark matter mass

# Plots to include for TDR

- **Neutrino background :**

  a. Neutrino Energy distribution at the production and after fiducial cut

  - b. Neutrino theta distribution (at production and fiducial cut)

  c. Normalized neutrino energy distribution

- **Neutrino electron scattering background:**

  a. scattered electron E distribution (before and after smearing)

  b. theta distribution

  c. Pz distribution

# Plots to include for TDR

- **Plot after cut :**

  a. Energy cut : (Energy distribution of both signal and background events after cut)

  b. Theta cut: (Theta distribution both signal and background after cut)

- S/√B as a function of dark matter mass and Y value (as in the parameter list)
- Y vs dark matter mass for different number of events
- Y vs DM mass 90% C.L.

# Final Plots for TDR

- **1. DM, Neutrino production energy spectrum**
- **2. DM, Neutrino energy spectrum at the detector**
- **3. Signal and background reconstructed energy**
- **4.Signal and background reconstructed theta**
- **5. Scatter plot of S/√B for the DM parameter space**
- **6. Y vs DM mass**
- **7. Y vs DM mass 90% C.L. plot**